Fisheries and Oceans Canada | Pêches et Océans Canada
Ecosystems and Oceans Science | Sciences des écosystèmes et des océans

Canadian Science Advisory Secretariat
Science Response 2018/041

Pacific Region

HARVEST ADVICE FOR PACIFIC SARDINE (*SARDINOPS SAGAX*) IN BRITISH COLUMBIA WATERS FOR 2018 SEASON

Context

The northern subpopulation of Pacific Sardine (*Sardinops sagax*) in the eastern Pacific Ocean (California Current Ecosystem) has a distribution that can range between Baja California to southeast Alaska. In winter and spring months, most of this stock has the tendency to occur in waters off the California coast in association with spawning. Prior to, and during summer months, large aggregations of Pacific Sardine migrate from spawning habitat to more northern waters mainly to forage. Migratory patterns can be affected by age structure, population size and oceanographic conditions. Typically, most Pacific Sardine that migrate into British Columbia (BC) waters are the larger and older fish in the population. Pacific Sardine has not been fished in BC waters since 2012 due to reduced migration (a general absence of Pacific Sardine in BC waters) and formal fishery closures in 2015, 2016 and 2017.

To calculate potential harvest options for the BC sardine fishery, Fisheries and Oceans Canada (DFO) adopted a harvest control rule in 2013 that applies a harvest rate to an estimate of age-1 year and older (age-1+) biomass that exceeds 150,000 t (DFO 2013). As described in the 2013 Science Advisory Report, a range in harvest rates from 3-5% was selected to calculate potential harvest options. The age-1+ biomass estimate used in the harvest control rule is based on stock assessment efforts conducted by the United States (US) National Marine Fisheries Service (NMFS) of the National Oceanic and Atmospheric Administration (NOAA). An update to a 2017 stock assessment model of the northern subpopulation of Pacific Sardine was conducted by the US NMFS of NOAA in March 2018. Results from the 2018 update include information on stock status and forecasts of age1+ sardine biomass informed by data sets representing fishery landings, biological sample data and fishery independent surveys updated until December 2017 (described in Hill et al. 2018).

DFO Fisheries Management requested that DFO Science Branch incorporate the updated 2018 US stock assessment results into the 2013 BC fishery harvest control rule and provide harvest advice for Pacific Sardine for the 2018 season. Specifically, this Science Response (SR) provides information on the northern subpopulation of Pacific Sardine (associated with the California Current Ecosystem) to report on its biomass status, exploitation rates, commercial landings, and harvest options for the 2018 BC Pacific Sardine fishing season. Objectives of this report are to:

1. Report the results of applying the harvest control rule for a range of harvest rates from 0.03 to 0.05 in increments of 0.01, if the expected stock biomass is above the escapement buffer of 150,000 tonnes.
2. Identify uncertainties associated with harvest advice.

A formal Canadian stock assessment will not be undertaken in 2018 and the following advice is based on a multi-year method approved in 2013. As such, for a full understanding of Science recommendations, uncertainties, and future considerations, readers are referred the 2013 Canadian Science Advisory Secretariat (CSAS) Science Advice Report (DFO 2013).

This Science Response Report results from the Science Response Process of May 2018 on Harvest Advice for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for 2018.

Background

Population assessment

As stated above, the US NMFS assesses the status and population trends of the Pacific Sardine northern subpopulation in the eastern Pacific Ocean (also knowns as the California Current Ecosystem stock) using a Stock Synthesis model (Methot and Wetzel 2013, Hill et al. 2018). Since 2014, the annual Pacific Sardine stock assessment process has been conducted and updated in the spring. An update to the 2017 model was conducted in March 2018. The model is informed by data from a fishery-independent acoustic-trawl survey, fishery landings, and biological samples collected from 2005 to December of 2017 (Hill et al 2018).

BC Pacific Sardine fishery harvest control rule

In 2013, DFO Fisheries Management adopted a harvest control rule that incorporates a July estimate (forecast) of the population's age-1+ biomass, a cut-off value of 150,000 tonnes, and a harvest rate. The cut-off value of 150,000 tonnes is consistent with the cut-off value used in the US harvest guideline. The harvest rate is applied to the difference between the estimated age-1+ biomass and the cut-off. As described in the 2013 review (DFO 2013), a range in harvest rates (h) from 3-5% was selected in the calculation of potential harvest allowances. The equation for the calculation of a fishing season's potential total allowable (TAC_t, tonnes) for a season starting in year "t" is:

$TAC_t = h\,(B_{1+,t} - 150{,}000)$,

where

h = harvest rate

$B_{1+,t}$ = forecast age-1+ biomass (tonnes), July

150,000 = cutoff value (tonnes)

When the forecast of age-1+ biomass ($B_{1+,t}$) is less than 150,000 tonnes, the recommendation is that there should be no harvest. This SR provides the recommended 2018 BC Pacific Sardine fishery harvest options based on the use of this harvest control rule and the 2018 NOAA forecast for the stock's July 2018 age-1+ biomass.

Analysis and Response

Biomass

Estimates of the California Current Pacific Sardine age-1+ biomass showed a decreasing trend since 2006, reaching historically low levels in recent years (Hill et al. 2018). Declines in recruitment have also occurred since 2005-06, with the exception of a brief period of modest recruitment success from 2009-10 (Hill et al. 2018). In particular, the 2011- 2016 year classes have been among the weakest in recent history. A small increase in recruitment was estimated in 2017, albeit a highly uncertain estimate (CV=77%) and based on limited data. The age-1+ biomass maximum likelihood estimate for the July 2018 forecast is 52,065 tonnes (with a 90% credible interval of 32,129 to 72,001 tonnes; Hill et al. 2018).

Few or no sardines have been observed in BC waters during 2013-2017 in fisheries, surveys or other sources, suggesting curtailed migration and/or stock size. Average estimates of Pacific Sardine trawl catch densities (a catch per unit effort index) from a west coast of Vancouver Island summer pelagic ecosystem night trawl survey in 2006, and 2008-2014 show a decreasing trend from 2006 with no sardines observed the last two years the survey was conducted (2013 and 2014). During the summers of 2015 and 2016 sardines were detected off the west coast of Vancouver Island in trawl catches from other multi-species surveys (i.e. led by DFO or NOAA) but none were detected in 2017.

BC fishery exploitation

The commercial BC sardine fishery was re[illegible]ted in 2002 following closure since 1947 (Ware 1999, DFO 2012). Most fishing occurred from July to October in association with seasonal sardine migratory behaviour (DFO 2012). From 2002-2012, the annual total allowable catch (TAC), generally increased as a result of management decisions (DFO 2012). Prior to 2008, landings were relatively low (less than 5,000 tonnes), increased considerably from 2007-2012 (up to a maximum of 22,223 tonnes in 2010) but were zero in 2013 through to 2017 due to an apparent absence of Pacific Sardine in BC waters in 2013 and 2014 and fishery closures in 2015, 2016 and 2017 (Table 1). Since 2002, total landings of the northern subpopulation (catches from BC, Washington, Oregon, California and Ensenada Mexico combined) were highest in 2007 and lowest in 2016. BC annual fishery exploitation rates were estimated as the annual fishery landings (C_t) divided by the estimated age-1+ biomass in July of year t. Exploitation rate estimates on the stock due to fishing in BC waters show an increase from ≤ 1% prior to 2009 to a peak in 2012 (between 5 and 6%), followed by 0% in 2013-2017 (Table 1).

*Table 1: A summary of recent Pacific Sardine fishery BC TAC, BC landings and total landings of the northern subpopulation for the west coast of North America (BC, Washington, Oregon, California and Ensenada Mexico). Also shown are Hill et al. (2018) estimates of July age-1+ population biomass ($B_{1+, July}$) and coefficients of variation (CV), and BC exploitation for years 2005-2016. Total landings for 2002-2005 are from Hill et al. (2016) and total landings for 2006-2017 are from Hill et al 2018 (*2017 total landings are preliminary). TAC, landings, and biomass values are in metric tonnes.*

Year	BC TAC	BC Landings (C)	Total Landings	Biomass $B_{1+, July}$	CV ($B_{1+, July}$)	BC Exploitation ($C/B_{1+, July}$)
2002	5,040	822	96,344	-	-	-
2003	9,000	1,006	84,311	-	-	-
2004	15,000	4,259	87,699	-	-	-
2005	15,200	3,266	94,149	1,534,415	10.18%	0.21%
2006	13,500	1,558	92,413	1,774,784	7.27%	0.09%
2007	19,800	1,507	134,366	1,471,710	6.40%	0.10%
2008	12,491	10,435	112,959	1,097,736	6.33%	0.95%
2009	18,196	15,334	100,084	755,371	6.20%	2.03%
2010	23,166	22,223	97,870	594,343	6.28%	3.74%
2011	21,917	20,719	91,890	532,226	6.75%	3.89%
2012	27,279	19,129	121,920	340,875	7.89%	5.61%
2013	25,477	0	73,595	170,633	11.63%	0.00%
2014	17,174	0	23,581	81,648	16.77%	0.00%
2015	0	0	2,994	65,405	20.56%	0.00%
2016	0	0	559	57,067	20.08%	0.00%
2017	0	0	*8,461	43,483	19.60%	0.00%

Uncertainties

Key uncertainties associated with the 2017 US Pacific Sardine assessment identified in Hill et al. (2018) and STAR (2017) include information related to:

1. acoustic species identification, target strength estimation and spatial boundaries associated with the acoustic-trawl survey. Concern over poor near-shore survey coverage has also been expressed by representatives of the U.S and Canadian sardine fishing industry.
2. empirical weight-at-age data from the fishery and research survey samples and model characterization of population weight-at-age (e.g. time varying versus time-invariant);
3. age-length keys to convert acoustic-trawl survey length compositions to age compositions and selectivity parameterization for the acoustic-trawl survey;
4. lack of empirical justification for increasing natural mortality from 0.4 to 0.6 yr-1; and

Uncertainties and concerns identified in past DFO CSAS reviews related to BC Pacific Sardine fishery harvest advice (e.g. DFO 2013) include:

1. the effect of setting harvest allowances independently of the US and Mexico;
2. unknown effects on stock structure and reproductive capacity from fisheries in different regions targeting different age components of the population;
3. incidental capture of other species in the sardine fishery; and
4. the effects of removing sardine from important forage habitat of sardine predators.

Harvest options

The July 2018 forecasted age-1+ biomass is 52,065 tonnes, which is below the fishery cut-off of 150,000 tonnes. Based on the harvest control rule adopted in 2013, the current recommendation is that there should be no allowable fishery harvest, thus, a TAC of 0 tonnes is recommended for the fishing season starting in 2018.

Conclusions

It is recommended that there should be no allowable targeted harvest of Pacific Sardine in BC waters in 2018.

Contributors

Contributor	Affiliation
Linnea Flostrand	Lead author, DFO Science, Pacific Region
Jennifer Boldt	Author, DFO Science, Pacific Region
Chris Grandin	Author, DFO Science, Pacific Region
Lesley	Editor, DFO Science, Pacific Region
Bradley Langman	Reviewer, DFO Fisheries Management, Pacific
Brenda Spence	Reviewer, DFO Fisheries Management, Pacific Region
Larry Johnson	Reviewer, First Nation Sardine Association
Lorne Clayton	Reviewer, Canadian Pacific Sardine Association
Kevin Hill	Reviewer, NOAA, Southwest Fisheries Science
Barron Carswell	Reviewer, Province of British Columbia

Approved by

Carmel Lowe
Regional Director
Science Branch, Pacific Region
Fisheries and Oceans Canada

May, 24 2018

Sources of Information

DFO. 2012. Pacific Region Integrated Fisheries Management Plan for Pacific Sardine (June 1, 2012 to February 9, 2015). (Accessed May 15, 2018)

DFO. 2013. Review of harvest control rules for Pacific Sardine and seasonal biomass and migration in British Columbia for 2013. DFO Can. Sci. Advis. Sec. Sci. Advis. Rep. 2013/037. (Accessed May 15, 2018).

Hill, K.T., Crone, P., Dorval, E. and Macewicz, B.J. 2016. Assessment of the Pacific sardine resource in 2016 for U.S.A management in 2016-17. Pacific Fishery Management Council, April 2016 Briefing Book, Agenda Item H.1.a. Portland, Oregon. (Accessed May 15, 2018)

Hill, K.T., P.R. Crone, J.P. Zwolinski. 2018. Assessment of the Pacific sardine resource in 2018 for U.S. management in 2018-19. Pacific Fishery Management Council, April 2018 Briefing Book, Agenda Item C.5, Attachment 1. Portland, Oregon.

Methot, Jr. R.D. and C.R. Wetzel. 2013. Stock synthesis: A biological and statistical framework for fish stock assessment and fishery management. Fisheries Research 142:86-99.

STAR (Stock Assessment Review). 2017. Pacific sardine STAR panel meeting report. A. Punt (chair), W. Satterthwaite, E. Brown, J. Vølstad, G. Melvin. Review: NOAA Fisheries, Southwest Fisheries Science Center, La Jolla CA, 92037, February 21-24, 2017. Report: Pacific Fishery Management Council, April 2017 Briefing Book, Agenda Item G.5.a, Portland, Oregon. (Accessed May 15, 2018)

Ware, D.M. 1999. Life history of Pacific sardine and a suggested framework for determining a B.C. catch quota. DFO Can. Sci. Advis. Sec. Res. Doc. 1999/204. 19 p. (Accessed May 15, 2018)

This Report is Available from the

Centre for Science Advice
Pacific Region
Fisheries and Oceans Canada
3190 Hammond Bay Road
Nanaimo, BC V9T 6N7

Telephone: (250) 756-7208
E-Mail: csap@dfo-mpo.gc.ca
Internet address: www.dfo-mpo.gc.ca/csas-sccs/

ISSN 1919-3769
© Her Majesty the Queen in Right of Canada, 2018

Correct Citation for this Publication:

DFO. 2018. Harvest Advice for Pacific Sardine (*Sardinops sagax*) in British Columbia Waters for 2018. DFO Can. Sci. Advis. Sec. Sci. Resp. 2018/041.

Aussi disponible en français :

MPO. 2018. Avis sur les prélèvements de sardines du Pacifique (Sardinops sagax) dans les eaux de la Colombie-Britannique pour la saison 2018. Secr. can. de consult. sci. du MPO, Rép. des Sci. 2018/041.